

Part #47

Rotax Piston Maintenance

by Mike Stratman

You want to do the right thing. Your Rotax has been a rock... taking you places that.....well maybe.....you shouldn't have been. You got more hours than the Scheduled Maintenance Chart calls for.....is it time to decarbon?? Here lies one of the most common yet misunderstood procedures. Piston maintenance is arguably the single most important item in the maintenance program. With the price of parts being what they are, it may not only be unnecessary to replace certain wear parts, it could be down right expensive.

This month we'll take an in depth look at everything you should know before tackling a "top end job" on your Rotax. When it's time to do it. What you need to get started. Knowing what to look for when inspecting parts and when to junk them. The do's and don'ts to know when cleaning parts. We'll also give you some hints on how to work with cageless wrist pin bearings and circlips without going insane.

At first glance I could have said this was a fairly short subject matter. But as I tapped into my usual sources of reliable technical info I found a lot more to this subject than I could imagine. Doing this job right requires a keen eye on what to look for both before you get started and during the actual teardown. You can spend a lot of time and money replacing parts that are not even close to wear limits. The first thing you need to know is when it's time to decarbon.



When It's Time To Decarbon?? - Listed in the Rotax Scheduled Maintenance Chart (located in CPS catalog or available in plastic laminated 10"x14" format Part #451 for a couple of dollars) that you are suppose to live by religiously is the item #31 "Inspect ring grooves". This is shown to be required every 50 hours.

Also, if you have experienced an unexplained engine failure, I would be performing the following procedure immediately. You could be a victim of the "Self Healing Engine Syndrome". See Part #27 "Blown Pistons Tell the Story". This is actually a simple procedure you can perform yourself in just a few minutes with the right tools.

First, give the engine a compression test. (Not to be confused with a leak test). This is done with the ignition switch off and all the spark plug caps removed. Good compression should read between 100-120 psi in both cylinders and equal at a minimum of 300 rpm (average for recoil starters, electric starters average around 800 rpm) on a warm engine. If compression is below 80 psi or more than 10% different between cylinders, you likely have a problem that will require a teardown. If you do not have a compression tester I recommend you invest in one. The type that screws into the spark plug hole is ideal. See illustration. This allows you to perform the test unassisted and with more accurate results. Again you must get 300 rpm or full starting rpm to get an accurate reading. Propping the engine will result in pitifully low compression readings. Use a vigorously pull on the starter rope or electric starter to get sufficient rpm.



Secondly, remove the exhaust manifold and inspect the piston and ring groove carefully. Look for scuffed pistons, jammed rings, or excess carbon on piston dome (.040" or more can result in contact with cylinder head). Remember you are looking at the area of greatest heat as the exhaust gas exits the combustion chamber. With a flashlight inspect carefully the relationship between the rings and piston grooves. What you should see is oil ooze in the ring groove as you rock the piston up and down with the prop. This indicates the rings are free to function properly. At this point if everything is OK, replace the exhaust manifold using new gaskets and go fly. If you have found evidence that problems exist you can feel confident that a teardown is in order.

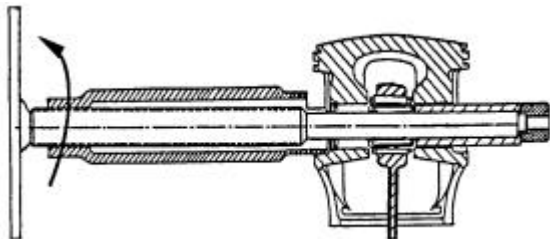
What Would Cause Excessive Carbon Build Up? - Here is where many factors may be at work. Here is where investing in a good grade of lubricant pays off. The better grades of lubricants will burn cleaner and promote better

lubrication than the cheaper grades of regular mineral based oils. It is general recognized that spending a little more for a specialized lubricant will extend your decarbon period. See "The Proper Care & Feeding of the Rotax Motor" Part #23 "Understanding Two Cycle Lubricants" for more information on choosing the right lubricant. Gone are the days where "the oil" took the complete rap for excessive carbon. While your choice of two cycle lubricant will have an effect on the periodic buildup of carbon deposits, it is likely to have contributed a small part of the deposits. With the quality of fuel being more and more suspect, water and incompatible gasoline additives are the major sources of deposits. See Part #19 Taking Control Of What Your Engine Burns" for more on this rather complex subject.

Some people have tried various products to clean the motor by spraying a snake oil solution into the Carbs while the engine is running. All kinds of strange results have been reported. Slick 50 or similar Teflon treatments work so well that the compression is drastically reduced. Other cleaners have caused greatly accelerated ring wear making for excessive ring gaps. As you can see there is no quick and easy way to decarbon a two stroke motor.

Getting Started - Now that you have properly determined it's time to teardown. Remove both intake and exhaust manifolds. Remove cylinder heads and mark with either "M" or Magneto side or "P" for Power Take Off or gear box side so they can be replaced in the same location. Likewise, mark each piston so it can be returned to the same location if necessary. Removing the pistons requires special considerations due to the cageless wrist pin bearings.

Personally I believe it to be nearly impossible to remove this type of bearing intact. Turn the engine up side down so the 31 tiny needles will fall into the piston cup when the wrist pin is removed. If this is not possible, make absolutely certain to capture all of these needles. Letting them fall into the crankcase is asking for a disaster! Just one of these needle running loose in the lower end will literally destroy everything in sight! Rotax does make a removal tool #877-090 Piston Pin Extractor (see illustration) that will remove the wrist pin as well as



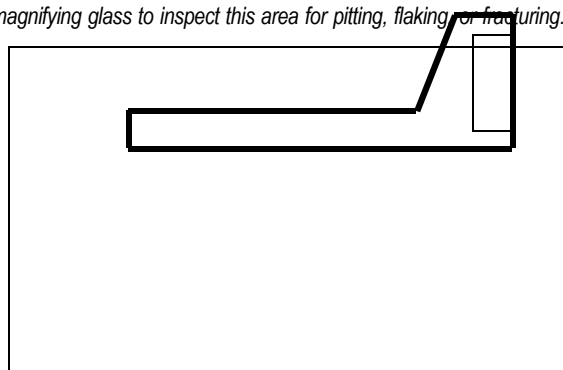
leave a temporary slug behind to contain the needles. If you are determined to remove these needles as a unit use the installation procedure described later in this article in reverse to control these little guys.

Once the wrist pins are removed, remove the marked pistons from the engine. Carefully remove the rings from each piston by bracing one ring end against the positioning pin and working the rest of the ring off the piston using light hand pressure only. Do Not use a ring expander.

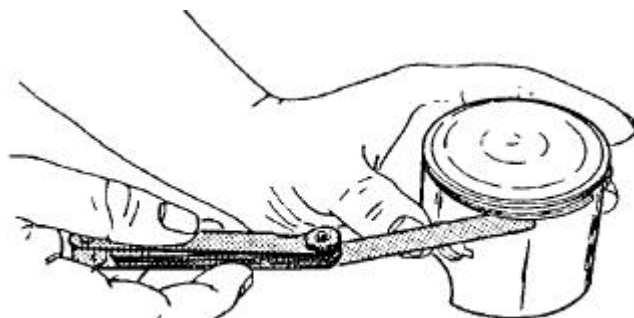
Parts Inspection - Knowing when to replace a piston ring has a lot to do with knowing how it is made and why. The top ring or semi-trapezoid ring is a composite ring made from two different types. See illustration for a side cut away view of this ring. The outside area of the ring where it contacts the piston walls is inlaid with a special molybdenum compound (atomic number 42). This alloy is recognized to run much cooler than the surrounding metals and makes for an extremely durable ring. It also has a lot to do with \$40 each. Use a magnifying glass to inspect this area for pitting, flaking or fracturing. Discard ring only if this area is damaged. Because the ring is located in sight of the spark plug the ring is thrust into the cylinder walls with each revolution. This produces a very tight seal and also makes it difficult for this ring to jam as opposed to the lower ring. The bottom area of the ring should be polished due to it's constant interaction with the piston groove. Inspect to see that this area is functioning normally without hot spots or unusual wear. Discard ring or piston w/ ring if improper wear pattern exists in this area

The lower ring is more like to jam because it is held against the cylinder walls by it's elastic properties only. For this reason debris from scuffed pistons or excessive carbon commonly finds it's way into this ring groove. Extreme care needs to be taken when attempting to remove this ring. Be sure to soak the piston overnight before attempting to remove. Breakage is a real possibility.

Flank Clearance: Measuring the flank clearance with a feeler gap is shown in the illustration here. This should be between .002" to .003" with a wear limit of .008". This is done on the

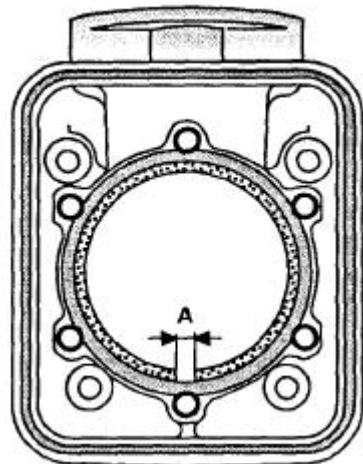


lower ring only.



This may come as a surprise to many that this ring can be removed without a significant lose of compression. In fact it is not present on many high rpm or racing applications. It does help stabilize the piston and prevent excessive slap which does increase piston life considerably.

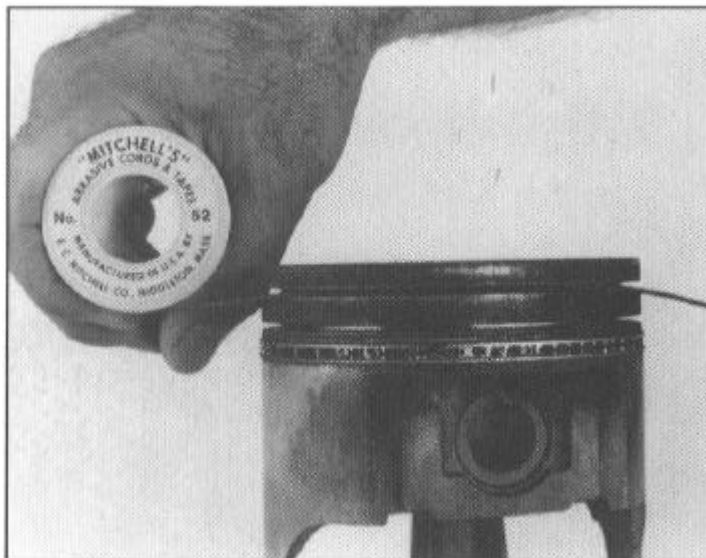
Ring End Gap: Both top and bottom rings should be checked for end gap. This is done by installing the ring by itself into the top of the cylinder bore as shown in the illustration. The ring gap "A" should be .012" to .017" with a wear limit of .039". You will find that wear in this measurement to be minimal unless your engine has been exposed to an intense gritty environment. You may also wish to check the pistons and cylinders for out of roundness while you have the chance. See your engine's service manual for procedures, specs, and tolerance.



Cleaning the Parts - There is most definitely a right way and a wrong way to clean the components. The real temptation is to just blast the deposits off the piston with a wire buffing wheel. Just take a few minutes...right? Fact is this will actually ruin the piston. Run your finger nail lightly down the sides of a piston. Notice the fine knurled finish. This finish allows a thin film of oil to sit on this surface where it reduces friction with cylinder walls. Remove this knurled finish and the piston is junk. There are several ways we can clean pistons without compromising the piston's finish. Soaking pistons overnight in a cleaning solvent like Berryman's Chemtool or similar solvent is a good start. Berryman makes a neat kit that includes 48 oz. of cleaning solvent, soaking basket, and cleaning brush inside a resealable can. This is the ideal size for pistons, Carb parts, and other small parts. The fluid is compatible with aluminum and works well to remove carbon and tar on pistons. The can be reused a number of times before the solvent starts to fade. The kit sells for around \$12 (Part #9579). A good investment when



field cleaning smaller parts. Rotax strictly specifies no caustic or acid cleaning solvents.



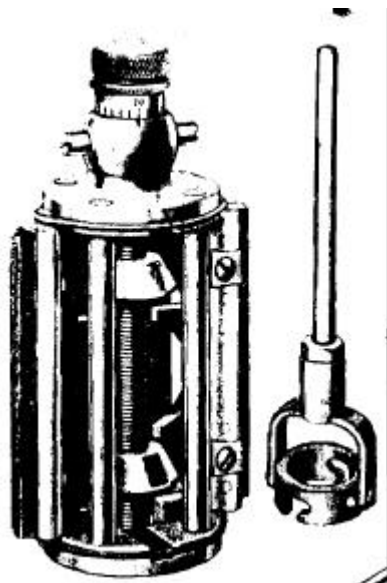
After soaking parts overnight, rings can be removed and the grooves cleaned thoroughly. If you plan on using the same rings again you must clean both the ring and the piston groove completely of all deposits. Use an exact-o-knife or similar picking tool to scrap even the smallest deposits off. This is a time consuming tedious job that is much like going to the dentist. Another method that speeds things up that works much quicker than picking is to use an abrasive cord inside the grooves. This product is used much like dental floss and does an excellent job of cleaning the toughest deposits from all areas of the ring groove in short order. See illustration. Sells for about \$1 per foot.

If you are still having a difficult time removing the deposits and want to speed things up you may resort to air blasting. Never use sand or glass beads! If you have access to plastic or walnut media use no more than 20 to 40 psi pressure. If the tar or brown color wont come dean it's really no big deal. This is purely cosmetic. When you are finished both rings should spring back out of grooves when compressed without any hesitation. Only at this point have you done the job properly.

Piston domes can be buff lightly with a wire wheel. No knurl to worry about here, just don't get stupid and change the shape of the dome. A brass brush is another way to remove carbon without damaging the piston. You may find a coking or an unusual build up inside the piston dome. This is common only on

inverted motors (another negative on inverted engines). When the engine is shutdown the fuel/oil mix runs down the connecting rod and collects in the piston dome where it can be baked by the residual heat of combustion. While this causes no immediate problem, a piston imbalance could result if enough material is allowed to build up.

A word of caution about pistons. Rotax pistons (Elko brand) are constructed of a minimum of 25% silicone composite alloy. Many after market pistons contain less than 15% of this alloy which makes them much more likely to seize in a tight fitting cylinder bore.

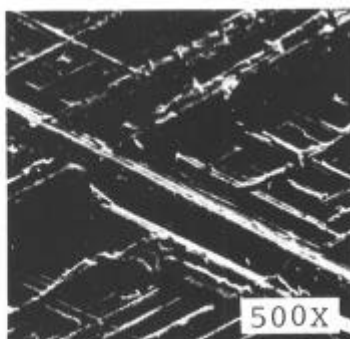
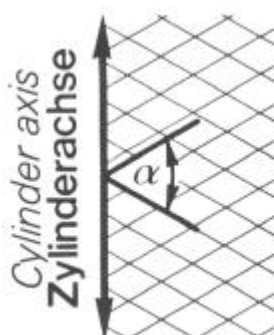


Reworking The Cylinders - If you have opted for new pistons or rings you must clean bore the cylinders. Setting up a new wear pattern is essential to good compression when working with new parts. Often times even if a piston has seized, the cylinder walls will not be scratch enough to require oversize boring because the piston is made of softer aluminum and "looses" badly to the much harder iron cylinder walls during a seizure. You can use a self-centering bore device with stones no finer than 150-200 grit stones. Boring .001" to .002" may be enough to remove scratches and still be well within factory clearance specs. Mbre often than not this will be your most cost effective option. After using a boring jig you will need to chamfer the ports to relieve sharp edges. This can be accomplished by hand using emery cloth or a fine file. A course grit Flex-Hone shown in illustration is ideal for chamfering ports. The brush like stones also do an excellent job of leaving the desired cross-hatch pattern. Don't expect the Flex-Hone to remove scratches. You will grow old waiting for even this to happen.

See illustration for a 500x magnified cross up of the finished surface. As you can see there is anything but a smooth surface here. This is where a thin film of oil clings to reduce friction.

Obviously this whole process takes several specialized tools. You may want to make the investment to be able to do the work yourself, pool

together with your flying buddies or club members, or pay a Rotax repair station to perform the work. In any event you may want to line up your ducks before getting started to avoid downtime. Before the end of this article we'll summarize all the tools we discussed for easier reference.



$$\alpha = 30^{\circ} - 60^{\circ}$$

Installing Cageless Bearings - Maintaining your sanity is key to performing the next few steps. Letting any of the needles fall into the crankcase area is not an option. As mentioned before, even one of these needles will literally grenade a motor! There is only one way to install wrist pin bearings, step by step and with the proper tools and techniques.

Step #1- Remove both circlips from piston. Place rag in opening to lower crankcase to prevent parts or debris from entering this area.

Step #2- Find a deep socket (possibly 10mm or 3/8" size) or similar cylindrical object that will pass snugly yet easily through piston pin passage. Should be about 2 1/2" long by 11/16" diameter. This is essential especially if the wrist pin is used or does not slide easily through the piston with just light pressure. Without this deep socket, alignment of parts is extremely difficult especially if you have to tap the wrist pin with a mallet.

Step #3- Replace both internal locking holders inside the cageless assembly with the #14003 tool (available for around \$2). This is best done one side at a time. Care must be taken not to allow the needles to become unsupported at any time. Be sure to include both thrust rings supplied with the cageless assembly.

Step #4- Slide outer plastic cylinder off as the bearing and tool are slipped into connecting rod eye.

Step #5- Place piston over connecting rod eye. Piston **must** be installed with ring gap toward intake side of engine or the arrow on top pointed toward the exhaust ("AUS" is the German abbreviation for exhaust)

Step #6- Insert deep socket into piston pin passage pushing temporary slug #14003 out the other side of the piston. This allows for easier alignment of the much tighter fitting piston pin later. Use index finger to slow #14003 slug as it is pushed through. Both pieces must be in firm contact at all times.

Step #7- Slide piston pin into place and tool out always keeping both pieces in firm contact at all times. Use a light tap with a soft mallet if necessary to move the tight fitting piston pin into place.



Installing Circlips - Again, here is where a little technique goes a long ways in making this step not that difficult. Do it any other way and you become incredibly frustrated.

Step #1 - With the piston dome being at 12 o'clock, install circlip into it's groove with one end at the six o'clock position.

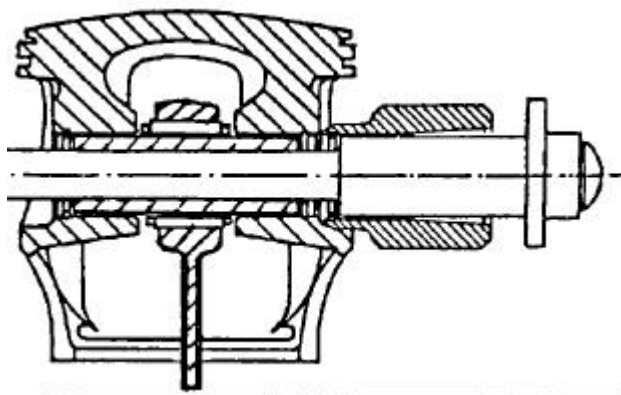
Step #2 - Place your thumb at the 3 o'clock position on the circlip and push down and toward the center of the hole.

Step #3 - Using the blunt end of a large flat head screwdriver start at the 10 o'clock position and push straight in at the point where the circlip enters the passage. If done properly you should hear an snap as the circlip passes the edge of the opening.

Step #4 - Move in a clockwise direction snapping the circlip into the opening a little at a time.

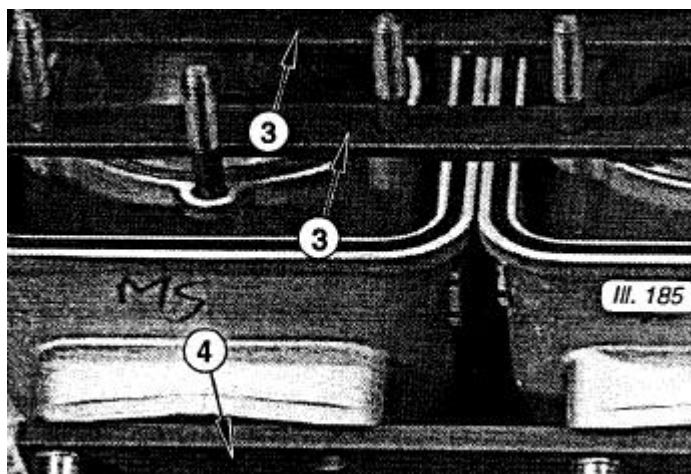
With a little practice this should take you less than 20 seconds per circlip. Novices may want to have extra circlips on hand in the event you launch one across the shop and can't find it. In any case under no circumstances are you allowed to bend, crush, or otherwise distort the circlip in an effort to get it into it's groove!

If you just can't master the screwdriver technique, Rotax does make a circlip installation tool Part # 877-015 (around \$70) that is used on the production line. No technique is required with the tool, just a big hammer. Don't feel bad about buying the tool, you wouldn't be the first. See illustration for circlip installation tool as work. Before installing cylinders take one last look to be sure you installed all four circlips.



Installing Cylinders Over Pistons - Once again a little technique makes this fairly simple. After installing the base gasket, place a rubber handle pliers or similar support across the crankcase with the connecting rod between the handles. Turn the crank till the piston skirt rests on the pliers holding the piston level to accept the cylinder. With your finger run a light coat of lubricant (same as you are going to run, AV-2, Pennzoil, etc.) inside each sleeve. Some people get stupid and soak everything with oil during assembly. This does little more than create a lot of smoke and excess carbon when the engine is started.

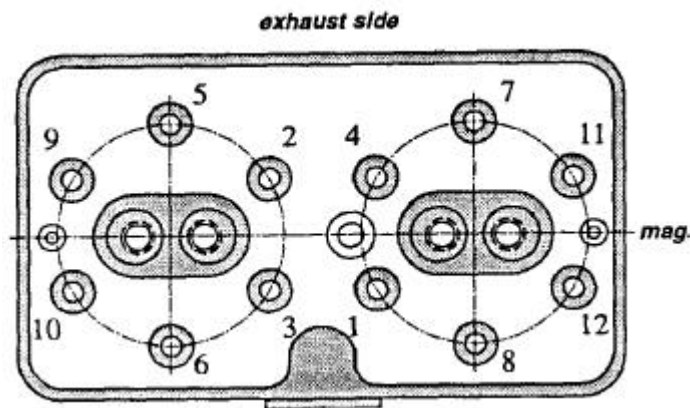
Lower the cylinder on to the piston using the tapered bottom of the sleeve to start the rings into their grooves. Make sure the position pins and the ring gap match up. Use a flat head screwdriver to push the ring back into the groove. Do not use any kind of ring compression tool. Work the cylinder on to the piston carefully. Don't force anything, go get some help if two hands are not enough.



Cylinder Alignment Tools - Clean both manifolds thoroughly and prepare them for installation. Before you bolt them up there are some alignments that must be considered. On the air cooled motors the intake and exhaust manifolds should be torqued up (18 ft.lbs.) prior to tightening the head studs. Doing head studs first could result in misalignment and manifolds that don't align and leak. On liquid cooled engines the gap between the heads is critical. Too close together and the cylinder can vibration against each other causing considerable noise and eventually breakage. Use of proper alignment bars will assure proper spacing as well as prevent manifold leaks. See illustrations of alignment bars.

Reuse Of Head Gaskets Or Oil Rings? - Rotax uses a special silicone o-rings to seal the top of the combustion chamber on it's 532-582-618 engines. The good part of this is that silicone resists heat fatigue. The bad part is they cost better than \$10 each! Careful inspection can save you some money here. Check the orings with a magnifying glass for cracking or deforming. The o-ring must still be round and not take an imprint when pinched with the fingernails. If you are satisfied that these orings pass this inspection, reuse them and save the money. The outer square type rubber rings that seal the outside perimeter of the cylinders should not experience excessive heat unless you have run water temps over 200F for extended periods. Check them for heat fatigue, replace if cracked, torn or deformed. Cost is minimal here. Base and intake gaskets can be used again if not torn. Aluminum head gaskets can be flipped over and used a second time only if no edge extrusion is visible. Always replace the exhaust gaskets.

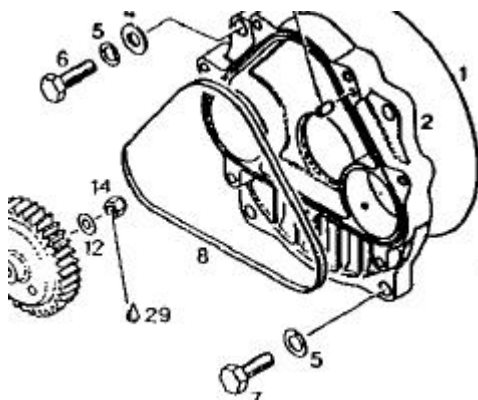
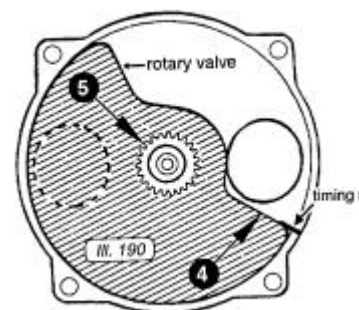
On air cooled engines the head gaskets can be reused if flipped over and retorted to 18 ft.lbs. Run the engine at least two hours, let set over night and then retorquing all fasteners. See accompanying illustration for torquing sequence. If you are not sure about specs, see CPS catalog for torque value and recommended sealant on all fasteners.



R retorquing Head Nuts - If you experience water leaks on head nuts on liquid cooled motors, chances are they are either loose or not installed properly. Use a small amount of Lithium grease at the base of the head nuts prevents galling and helps seal the flair on the bottom of the nut against the cylinder head. Note the flair shape of the head nut shown here. Use RTV Sealant under brackets and other items located under head nuts. This will keep fluid from passing around cylinder bolts.



Timing the Rotary Valve - On liquid cooled motors the Rotary Valve plate must be timed when installed. Place your dial indicator in the mag side cylinder and bring the piston to top dead center. Install the plate so that the opening is in the 11 and 4 o'clock position. The 4 o'clock or closing edge must be slightly below the bottom of the mag side port. See illustration. The plate is asymmetrical so flipping it over will give you more positioning options. If you where smart, a scribe mark before teardown would make this real simple.



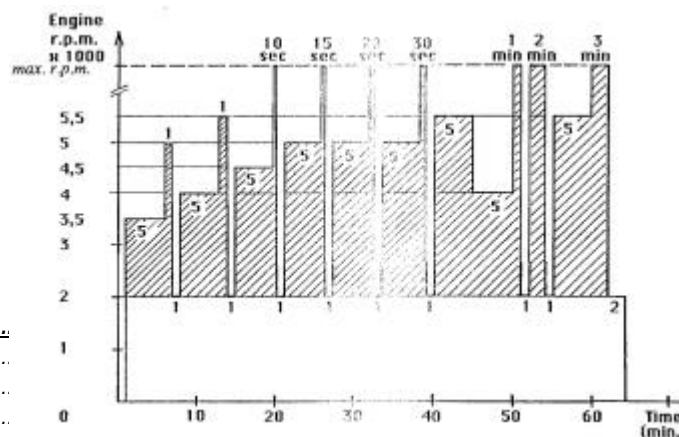
Installing the RV Cover Plate - On liquid cooled engines there is the opportunity to break the crankcase if you are not paying attention when installing the four 8mm fasteners that hold this cover. The mounting bolts are two different lengths and when installed in the wrong position can bottom on the crankcase. Another turn or two of the wrench and the ear of the crankcase can be broken. As you can see there is no fix for this disaster! Crankcases run around \$800. Work slowly and pay attention when assembling this area. See illustration for clarification.

Break-in Procedures - If you have replaced the piston rings and refaced the cylinder walls as previously mentioned, you must run the new engine break-n procedure. New rings and cylinder walls must reseal themselves by establishing a new wear pattern. Break-in is also described as a "controlled destruction". During the first few minutes of operation these new parts will wear at an accelerated rate. Controlling this destruction by following the 60 minute chart will mean a tighter seal and a better running engine. See illustration.

Tool and Parts Listing - As mentioned earlier, to make things easier the following is a list of recommended parts and specialty tools to have on hand to before getting started. We trust you have the common metric hand tools.

Specialty Tools

Tool Part #.....	Required.....	Recommended.....	
#14003 Bearing slug.....	X.....		
#877-090 Pin Extractor.....		X.....	
#876-358 Wrist Pin Puller.....	X.....		
#877-015 Circlip Tool.....		X.....	\$66*
#876-570 Exhaust Alignment Bar.....		X.....	\$25*
#876-900 Cylinder Alignment Bar.....		X.....	\$43*
#15009 Timing Tool Kit.....	X.....		\$89*
#T149 Torque Wrench.....	X.....		\$129*
#9529 Flex Hone.....	X.....		\$46*
#9531 Cylinder Bore Kit.....	X.....		\$449*
#9579 Parts Cleaning Kit.....	X.....		\$12*



Summary - *A properly functioning piston is at the heart of two cycle reliability. Piston maintenance is arguably the single most important item in the maintenance program. As we have discussed here there is a right way and a wrong way to approach this task. Armed with the proper information this procedure should no longer be the subject of misinformation or misguided hanger talk.*